

Memo

To: Malcolm Siegel, Ph.D.

From: Jim Studer

CC:

Date: 11/3/2001

Re: Technical Memorandum – Preliminary Engineering Cost Analysis of Hanford 100-N Area Remediation Scenarios Developed by the ITRD Program

This technical memorandum has been prepared in accordance with Sandia National Laboratories/New Mexico (SNL/NM) Contract Document Number 19942. The corresponding scope of services involved review of engineering cost analysis (ECA) procedures and, per our discussions, demonstration of certain ECA techniques through application to a specific environmental restoration site – in this case the United States Department of Energy Hanford 100-N Area. In particular, a Preliminary Engineering Cost Analysis (PECA) of the developmental plans for remediation of the 100-N Area was conducted; the results of which are presented herein. These developmental plans for remediation are described in the Draft 100-N Area Remediation Options Evaluation Summary Report (undated) prepared by the Innovative Treatment Remediation Demonstration (ITRD) Program at SNL/NM. The 100-N Area is the site of historical production and waste management activities located adjacent to the Columbia River. Site characterization has shown the site soils and groundwater to be contaminated with the radioactive element Strontium 90 (⁹⁰Sr) and other contaminants of lesser importance. The PECA included review of a number of selected documents and files, as well as compilation, calculations, and tabulation using selected cost estimate data of a preliminary nature. The overall objective of the PECA was to support ITRD's efforts in developing information on remedial scenarios for 100-N Area that will support decision making aimed at improved site management, treatment efficiency, and reduced overall cost. This document includes Attachment 1 – Cash Flow Analysis of Remedial Scenarios and Attachment 2 – Scenario Alternative A, 300-Year Projection. The primary mode of conveying this memorandum is by electronic mail and two separate electronic files are included. This memorandum is in Word 97 format and the tabulated data were prepared as a workbook using Excel 97. Paper hardcopies of this document have been prepared as well. The organization of the remainder of this memorandum is as follows: Summary of Information Reviewed; Situational Analysis; Description of Preliminary Engineering Cost Analysis Approach; Results; and Conclusions.

Summary of Information Reviewed

The information provided for review included the following:

- The draft ITRD report cited above;
- Several sets of ITRD meeting notes for meetings that took place in 1998;
- Three loose bound technical documents related to soil flushing (two documents) and phosphate stabilization studies (one document); and
- Two three-ring binders from the ITRD Program containing correspondence, meeting notes, proposals, technical documents such as laboratory findings and reports.

Situational Analysis

The draft ITRD report describes the site history and current situation. In summary, the 100-N Site is approximately 275 acres in area, is located within the general interior of the DOE Hanford Reservation, and is bounded on the northwest by the Columbia River. Disposal of radiologically contaminated reactor-cooling water effluent occurred at the Site until the early 1990s. Two Liquid Waste Disposal Facilities (LWDFs), 1301-N and 1325-N, were used for disposal. Idling of these facilities effectively eliminated the source of radionuclides to the subsurface. Widespread contamination of sediments and groundwater by ^{90}Sr , with long-term migration and release to the Columbia River is the primary concern at Site 100-N.

The current interim remedial action at the 100-N Area is a pump-and-treat system. The pump-and-treat system does not address contamination contained in the unsaturated zone. Monitoring of the groundwater during the pump-and-treat remediation operation, as well as numerical modeling, has generated information that indicates that contaminant plume contours are retreating.

The natural processes operating at the 100-N Area include radioactive decay and sorption. The half-life for ^{90}Sr is 28.6 years. This half-life indicates that natural radioactive decay will reduce the concentration of ^{90}Sr by 50% in less than 30 years and by 90% in approximately 95 years. The concentration of ^{90}Sr will decay to background levels in 10 half-lives or less than 300 years.

The amount of ^{90}Sr present in the saturated zone appears to be a small fraction of the contaminant mass inventory because the majority of the contamination is thought to be contained in the unsaturated zone below the LWDFs. The highest concentrations of ^{90}Sr in the sediment and pore water have been detected near the top of what is referred to as the operational water table, and decrease with depth to the current water table. According to the

draft ITRD report, ^{90}Sr contamination occurring in the unsaturated zone will decay before reaching groundwater despite the possibility of increasing recharge rates. Furthermore, numerical modeling indicates that only a small portion of the contamination contained in the saturated zone will reach the river over the next 300 years.

The 100-N Site, currently under interim containment, is in the process of final remedial planning. As of this writing, removal of the highly contaminated soils in and directly below the 1301-N and 1325-N LWDFs is planned and underway. DOE and contractor management has engaged with the ITRD Program to assist in development of final remedial scenarios based in part or in whole on innovative technologies. The draft ITRD report describes the innovative technologies passing initial screening, the five remedial scenarios under development, and corresponding rough cost estimates for these scenarios as of the second quarter of fiscal year 2001.

Description of Preliminary Engineering Cost Analysis Approach

As stated previously, the purpose of the PECA was to support ITRD's efforts in developing information on remedial scenarios for 100-N Area that will support decision making aimed at improved site management, treatment efficiency, and reduced overall cost. The remedial scenarios evaluated during this PECA were developed over the period 1997 through 2000. A rough cost estimate for each scenario, covering capital, operational, and maintenance costs over a 30-year period, was also developed during this period. The estimated values are in constant 2000 dollars. Although documentation is not complete, it appears that certain assumptions upon which the rough estimates are based were not consistently applied across the scenarios.

The following outline sketches the approach utilized during the PECA to develop updated cost estimates that are more compatible with a relative comparison and contrasting effort aimed at identifying the most promising remedial strategy.

1. A determination was made that each of the five scenarios is predicated on ^{90}Sr containment and thus would involve approximately 300 years of O&M before site closure. A complete life-cycle analysis would require a 300-year analysis horizon.
2. A nominal 30-year analysis horizon was selected over which partial life cycle costs would be developed for comparison and contrasting purposes.
3. A cash flow analysis structure accommodating an initial capital outlay period and a 30-year duration O&M period was selected.
4. Each remedial scenario was reviewed to check major assumptions and identify significant modifications that would improve technical feasibility of individual scenarios, and consistency across scenarios. Treatability Studies and Proof of Principal field pilot tests

were assumed to occur before Year 1 of the cash flow analysis. Capital costs include all non-recurring planning/engineering, construction, and startup costs. Operations and Maintenance costs include all post startup costs, recurring or not. Specific technical modifications to individual scenarios are presented in the subsequent section presenting the results.

5. A cash flow stream was developed for each scenario assuming constant 2000 dollars and End-of-Year convention. For this analysis, "constant dollars" refers to dollars of average general purchasing power as of the base year 2000.
6. Annual capital and O&M costs were estimated. Total capital cost and total O&M cost was calculated by summing across the entire analysis horizon. Each annual cost in constant dollar values was converted to a Present Value (PV) by discounting the cash flows using a discount rate of 4 percent. This value is a relatively close estimate of published OMB discount rates for long project horizons. Total Project PV (often referred to as Net Present Value) was calculated by summing all the PVs across the analysis horizon. Escalation rate (i.e., inflation) was assumed to be zero. PV of a future payment is calculated as follows - $\text{Future Payment} \times (1 / 1 + d)^n$, where d is the corporate discount rate. n is the year, assuming n = 1 at the end of the first 12 month period.
7. Cash flows were developed over a 300-year period for Scenario A (Monitored Natural Attenuation) so that a more accurate depiction of the complete life cycle costs, in Constant Dollars and PV, could be presented.

The following sections presents the results and conclusions of the PECA.

Results

Attachment 1 presents the PECA results based on the nominal 30-year analysis horizon. The basis for each scenario is as follows:

Scenario A

Monitored Natural Attenuation (MNA) is conducted for 300 years. Costs for the first 31 years are presented. Capital costs are for a two-year study, design and permitting period including extensive site characterization, sampling, numerical modeling, and design of a long-term site monitoring and maintenance program. Costs to manage investigation derived waste, control vegetation growth, maintain the site security, perform history matching modeling and other analyses, and communicate with DOE, regulators, and the public are included for the 30 year O&M period. Long-term annual costs were increased as part of this PECA from the rough estimate of \$200,000 contained in the draft ITRD report to an estimate of \$400,000 in an attempt to more accurately represent the cost burden. The total estimated cost at year 31 is

\$15.4M, based on 2000 dollars. The Present Value of the cash flow stream through this period, assuming a 4 percent discount rate is \$10.9M.

Scenario B

Containment using a Permeable Clinoptilolite Barrier and MNA near the riverbank itself is conducted for 300 years. Costs for the first 31 years are presented. Capital costs are for a two-year design, permitting, and construction period. Costs to manage investigation derived waste, control vegetation growth, maintain the site security, perform history matching modeling and other analyses, and communicate with DOE, regulators, and the public are included for the 30 year O&M period. The total estimated cost at year 31 is \$19.0M, based on 2000 dollars. The Present Value of the cash flow stream through this period, assuming a 4 percent discount rate is \$14.2M.

Scenario C

Containment using chemical stabilization and an impermeable barrier is conducted for 300 years. Costs for the first 31 years are presented. Capital costs are for a two-year design, permitting, and construction period. Costs to manage investigation derived waste, control vegetation growth, operate the cryogenic process, maintain the site security, perform history matching modeling and other analyses, and communicate with DOE, regulators, and the public are included for the 30 year O&M period. Decommissioning of the impermeable barrier components is not included as it is assumed that these components will remain in place for the entire project duration. The rough estimate to apply the Tri-Sodium Phosphate (liquid phosphate or LP) was \$3.0M. This value was deemed to be too low considering the volume of the targeted treatment zone and the cost of delivery and materials. An adjusted estimate of \$7.5 M was developed for this analysis. The total estimated cost at year 31 is \$36.9M, based on 2000 dollars. The Present Value of the cash flow stream through this period, assuming a 4 percent discount rate is \$27.7M.

Scenario D

This scenario consists of treatment using soil flushing over a nominal seven-year period followed by containment using chemical stabilization, an impermeable barrier, and phytoremediation over a 300-year period. Costs for the first 31 years are presented. Capital costs are for a two-year design, permitting, and construction period with the capital expenditure period extending into Year 7 with the initial application of LP. Costs to manage investigation derived waste, control vegetation growth, operate the cryogenic process, decommission sections of the soil flushing well field, decommission and maintain the evaporation ponds (assumed to be 6 acres in area), reapply LP on 15 year intervals, maintain the site security, perform history matching modeling and other analyses, and communicate with DOE, regulators, and the public are included for the 30 year O&M period.

Decommissioning of the impermeable barrier components is not included as it is assumed that these components will remain in place for the entire project duration. The sequence of technology option application was reviewed and modified by delaying the LP application to the last year of soil flushing during which clean water will be circulated through the injection/extraction system. Benefits achieved by doing this include the application of LP after the bulk of removable ^{90}Sr has been extracted from the saturated zone, availability of the complete flushing injection and extraction system, and improved hydraulic control capability. The rough estimate to apply the Tri-Sodium Phosphate (liquid phosphate or LP) of \$3.0M was retained for this analysis because the volume of the targeted treatment zone is limited compared to Scenario C. The total estimated cost at year 31 is \$64.3M, based on 2000 dollars. The Present Value of the cash flow stream through this period, assuming a 4 percent discount rate is \$49.4M.

Scenario E

This final scenario consists of treatment using soil flushing over a nominal seven-year period followed by containment using chemical stabilization, an impermeable barrier, and MNA over a 300-year period. Costs for the first 31 years are presented. Capital costs are for a two-year design, permitting, and construction period with the capital expenditure period extending into Year 7 with the initial application of LP. Costs to manage investigation derived waste, control vegetation growth, operate the cryogenic process, decommission sections of the soil flushing well field, decommission and maintain the evaporation ponds (assumed to be 6 acres in area), reapply LP on 15 year intervals, maintain the site security, perform history matching modeling and other analyses, and communicate with DOE, regulators, and the public are included for the 30 year O&M period. Decommissioning of the impermeable barrier components is not included as it is assumed that these components will remain in place for the entire project duration. The sequence of technology application was reviewed and modified by delaying the LP application to the last year of soil flushing during which time clean water will be circulated through the injection/extraction system. Benefits achieved by doing this include the application of LP after the bulk of removable ^{90}Sr has been extracted from the saturated zone, availability of the complete flushing injection and extraction system, and improved hydraulic control capability. The rough estimate to apply the Tri-Sodium Phosphate (liquid phosphate or LP) was \$3.0M. This value was retained for the updated analysis because the volume of the targeted treatment zone is limited compared to Scenario C. The total estimated cost at year 31 is \$61.8M, based on 2000 dollars. The Present Value of the cash flow stream through this period, assuming a 4 percent discount rate is \$48.3M.

The calculated Net PV for the nominal 30 year analysis horizon along with the relative ranking of each scenario as determined through this PECA are shown on Table 1.

Table 1. Relative Ranking of Remedial Scenarios Based on PV for Nominal 30 Year Project Horizon

Scenario	Present Value, in Millions	Relative Ranking Based on PV
A	\$10.9	1
B	\$14.2	2
C	\$27.7	3
D	\$49.4	5
E	\$48.3	4

It is stressed that the cost estimates presented above are for a 31-year period. A comprehensive life cycle analysis of these scenarios over the anticipated 300-year remediation period may result in a re-ordering of the scenarios based solely on cost. In particular, the life cycle cost estimates for those scenarios that include significant multi-million dollar expenditures, capital or O&M, post year 31, would be expected to change significantly. The timing of those expenditures is important, however, as future outlays become less significant with increasing time. To demonstrate this point, a 300-year analysis was performed for Scenario A to show the influence of the time value of money. Attachment 2 summarizes Constant Dollar and PV estimates for 1, 30, 50, and 300 years from start of MNA program. Although escalation was not considered in these calculations, it is noted that a typical escalation rate between 2 and 7 percent would somewhat - to more than fully - compensate for the effects of discount rate, resulting in cost values of significantly greater magnitude than presented herein.

A constant discount rate (4 percent) and escalation rate (zero percent) was used for both the nominal 30 year and 300 year horizon analyses. It is important to note that the relative ranking of scenarios could also change if variable schedules representing specific rates for specific periods into the future were utilized.

Conclusions

The following conclusions were developed in the performance of the PECA:

- More reliable estimates of approximated (i.e., 30-year basis) life cycle costs were developed in the execution of the PECA. Although the relative ranking of scenarios by cost did not change from the initial estimates presented in the draft ITRD report, the bases for the estimates are clearer, the nominal 30 year cost of several scenarios changed significantly, and the potential for different rank outcomes given modest changes in engineering costing assumptions is now apparent. Other potentially important decision criterion not considered in the PECA (e.g., reliability, practicality (technical and programmatic), socio-cultural issues, and satisfaction of all regulatory requirements) could also have a significant role in the selection of the optimal scenario.
- Based on the PECA, the range in remedial costs over the 31-year horizon is \$15.4M to \$64.3M (2000 basis) and \$10.9M to \$49.4M (PV).
- Scenario A 30-year cost is \$15.1M while 300-year cost is \$99.4M (2000 basis). The corresponding PV estimates are \$10.8M and \$13.2M.
- Additional detailed engineering analysis of the design basis and technology options assemblies followed by detailed bottoms up cost estimating with subsequent ECA/value engineering of these estimates should yield significantly different results in terms of absolute estimated lifecycle cost and potentially the relative ranking.
- The differences between a 30-year analysis horizon versus a 300 years horizon is important. Any scenario that relies on insitu natural attenuation dominated by sorption and retardation processes should be evaluated against the 10 half-life measure. Soil flushing appears to be the only technology that is under consideration that could reduce the area of concern for long-term management by effectively removing contaminant from defined regions of the site. As a technology, soil flushing is the only technology under consideration that has the potential to remove enough ⁹⁰Sr mass from the site saturated zone that the time to achieve near background radiation levels (e.g., 8 pcuries/l) is materially reduced from approximately 290 years.

Attachment 1
Constant Dollar Cash Flow and Present Value Estimates
For Remedial Scenarios A - E

ITRD Hanford 100-N Project

Attachment 2
Constant Dollar Cash Flow and Present Value Estimates
For Remedial Scenario A
300 Year Duration

ITRD Hanford 100-N Project